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The Effect of Ultraviolet Irradiation on the Mineral and Nitrogen Metabolism of Adolescents.

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At present there are sufficient data on the investigation concerning the influence of sunlight on the animal and human organisms. As has been established by N. F. Galanin, A. P. Zabalueva, E. V. Donetskaia and T. A. Svinderskaia, G. M. Frank et al, due to the effect of ultraviolet irradiation, in the human organism are developed many complex processes in the skin and in reticuloendothelial and central nervous systems, vitamin D is synthesized, the immunity reaction is increased, the metabolism is stimulated.

The intensity of the sun's ultraviolet radiation varies in the different latitudes and also during the course of the day and year. According to the data of N. F. Galanin, about 70 % of the ultraviolet radiation occurs in 4 spring-summer months, there is little in the fall and practically none in the winter. The natural ultraviolet radiation of the sun is decreased by 20-30 % in large cities, due to the pollution of the atmospheric air by dust, smoke and gases (N. F. Galanin, B. V. Rikhter). The requirement in ultraviolet radiation for an organism is extremely great.

The lack of natural ultraviolet radiation can be made up by irradiation with artificial sources. The numerous experiments on animals and observations on humans indicate that artificial sources of ultraviolet radiation are completely active biologically.

According to the data of M. M. Dantsig, A. P. Zabalueva, Ia. E. Neyshtadt, I. K. Talanovskaia, A. F. Chernavinskaia et al, radiation from artificial sources leads to the formation of vitamin D, and to the normalization of the phosphorous-calcium exchange. However, as concerns the normalization of the phosphorous- calcium exchange, the investigators judged by biochemical examinations of the blood (by the content of inorganic calcium and phosphorus, by the activity of the alkaline phosphatase), by changes of the permeability of the capillaries and by roentgenographic investigations of the tubular bones. In the indicated works, as a rule, there was an absence of data concerning the quantitative and qualitative side of the feeding of the groups being investigated, and about the balance of calcium and phosphorus in the organism. Meanwhile, the normalization of the phosphorus-calcium exchange depends to a significant degree on the content in the food of calcium, phosphorus, magnesium, proteins, fats and some vitamins, and also on their relationships with each other.

Today it is generally acknowledged that the food allowances for the adult and particularly for the children's collectives do not always meet the

organism's demand for calcium. The deficit of calcium in the rations is stipulated by the fact that in the majority of the products consumed, the calcium is contained in small quantities, or in a form that is poorly assimilable. Meanwhile, we know the importance of calcium for the function of the central nervous system, for the blood-circulation organs, for the digestion, its influence on the coagulability of the blood, on the permeability of the cellular membranes, on the conducting of the nervous impulses. Calcium is also a plastic material for the synthesis of osseous tissue. The demand for calcium is particularly increased in the childhood and adolescent years, in the period of intensive growth and formation of the skeleton. A prolonged deficiency of calcium in the food will lead to a significant decrease in the general quantity of calcium in the organism that cannot but be reflected in the condition and physical development of children and adolescents.

In connection with what has been outlined above, a great actuality and practical importance are attained by investigations which are directed at a prophylaxis of the calcium deficiency in the feeding, particulary of children and adolescents.

In the department of nutritional hygiene of the Moscow Scientific Research Institute of Sanitation and Hygiene im. (in name of) F. F. Erisman, Ministry of Public Health, RSFSR, experiments have been conducted for the last 6 years on increasing the content of assimilable calcium in the food rations of children and adolescents, and on an investigation of factors which increase the assimilability of the food's calcium by a growing organism. Thus, in 1951-1953, on children 8-10 years of age, the question concerning the possibility of the use of calcium contained in some vegetables by a child's organism was investigated, in as much as vegetables rank second only to milk products in calcium content.

The physiological investigations conducted by us on metabolism in children, who were on a food ration with a predominance of groats, but containing some vegetables (carrots, white headed cabbage, fresh and fermented, cauliflowers and others), showed that the calcium contained in the vegetables is utilized to a significant degree by a child's organism. The balance and retention of the calcium upon substitution of a portion of the groats in the food rations by vegetables, by the whiteheaded cabbage and carrots in particular, was significantly increased.

In 1954 , in children 10-11 years of age, the influence of D vitaminization on the balance of calcium and other mineral substances was investigated. The investigations showed that a prophylactic 20-day vitaminization of school-age children with vitamin D_2 in a minimal dose (500 units) contributes to a better utilization of the calcium which is taken with the food.

The present work is a logical continuation of the investigations of the preceding years. Included in its aims is a further search for agents, which can be utilized in the prophylaxis of calcium deficiency. We investigated the until now little known subject of the influence of vegetables and ultraviolet irradiation on the mineral, and for the most part on the calcium exchange in youths (age 15-17 years).

In our investigations the study of the influence of ultraviolet irradiation was conducted on an established, carefully regulated feeding. A trade school, which trained mechanics in the repair of agricultural machinery, served as a base for our investigations. The living and working conditions in the school were satisfactory. The feeding of the trade school's students was carried out according to the norms which were approved in 1953. We made a tabulation of the calory content and nutritional value of the approved collection of products and food rations for the trade school's students (according to the data of the distribution menu for the 1955/56 academic year). An excerpt of the distribution menu was conducted for 6 days of each month by the method developed by the Institute of nutrition, AMN, USSR. The results of the tabulations are shown in table 1.

(Table 1)

From the data of table 1 it is seen that the actual composition of the food rations of the students in the trade school does not differ substantially from the approved collection of products. However, the content of proteins, fats and particularly fats in the student's food rations is significantly lower than the physiological norm for adolescents. The calcium content in the rations also proved to be low - 600-700 mg per 24 hours instead of 1000 by the physiological norm.

During the period of our observations the selected group of youths (13) were situated in conditions that are standard for trade schools. The youths were not torn away from the daily living and school schedule. The regime of work and feeding was preserved in its entirety for them also.

The ultraviolet-ray irradiation of the adolescents was done in the medical facility at the school. The mercury-quartz lamp, PRK-2 (without reflector), served as the source of radiation. The intensity of the ultraviolet radiation was measured by an ultraviolet meter from the All-Union Light Engineering Institute (construction by Engineer Shklover), the biological dose of the irradiations was determined individually with the Gorbachev biodosimeter. The average erythemal biodose at a distance of 1 m from the burner equalled 2 minutes, or 262 $\frac{\text{microvolt/min.}}{\text{cm}^2}$. The irradiation started with $\frac{1}{2}$ of the erythemal biodose, that is, for 1 minute, and was conducted within a day. In all, there were 20 irradiations. The exposure was gradually increased, and by the 20th irradiation, amounted to 6 biodoses. During the exchange investigations, the youths (4) were changed to an experimental food ration. The collection of products used in the experimental food ration was constant (table 2), the bill of fare was changed daily.

In the preparation of the food, the products were weighed separately for each youth. The youths ate the prepared food without leaving left-overs. During the exchange investigations the youths' water consumption was also taken into account. It was established that on an average the youths received 80 mg of calcium with their water in 24 hours.

The investigation of metabolism was conducted prior to and after the ultraviolet irradiation. Both in the first and also the second case, the observations were conducted for a 10 day period, of which 4 days were prior

to the test. During the days of the investigations, an account was made of the food consumed by each youth, and the excretions (urine, feces) were collected. The calcium, phosphorus, magnesium and nitrogen were determined in the material (food and excretions) received in the exchange investigations. The data received (expressed in average figures) are shown in graphs 1-4. The data on the study of calcium exchange in adolescents (prior to and after ultraviolet irradiation) are shown in graph 1.

(Graph 1)

As seen in graph 1 the calcium consumption with the ration prior to and after the ultraviolet irradiation was practically the same, and on an average amounted to 1,117 mg. in 24 hours. The calcium loss, particularly with the feces, was reduced after the youths' ultraviolet irradiation to 351 mg in 24 hours, as compared to 644 mg prior to irradiation. In relation to this the calcium balance increased from + 394 to + 697 mg in 24 hours, and the retention from 34.9 to 62.4 %. Therefore, after the ultraviolet irradiation the capability of the organism to retain the calcium from the food had increased. This provides a basis to consider its use in the plastic processes of a growing organism.

(Graph 2)
(Graph 3)

For a more complete picture of the changes in the mineral exchange under the influence of an ultraviolet irradiation, we also investigated the exchange of phosphorus and magnesium in the adolescents. In graph 2 are presented the data on the exchange of phosphorus in the youths (prior to and after the ultraviolet irradiation).

From graph 2 it is seen that the phosphorus balance in the youths after the course of ultraviolet irradiation was raised from + 382 to + 690 mg in 24 hours with an identical intake of it with the food. The phosphorus loss was curtailed significantly in the feces (from 496 to 354 mg per 24 hours) and particularly in the urine (from 800 to 603 mg per 24 hours). The retention of phosphorus in the organism was raised from 22.2 to 41.9 %.

In graph 3 are presented the data on the exchange of magnesium in the youths (prior to and after the ultraviolet irradiation).

From graph 3 it follows that the balance of magnesium after the ultraviolet irradiation also raises from + 88 to + 117 mg per 24 hours due to the curtailment of the extraction of magnesium by the feces from + 385 to + 283 mg per 24 hours.

(Graph 4)

In graph 4 are shown the results of the study of the nitrogen exchange in the youths (prior to and after the ultraviolet irradiation).

As seen in graph 4, the consumption of nitrogen with the food prior to and after the ultraviolet irradiation was identical and amounted to, on an

average, 17.6 mg per 24 hours. After the ultraviolet irradiation the extraction of nitrogen by the feces and particuäarly by the urine was reduced from 11.21 to 9.8 g for 24 hours. The increase of the nitrogen retention from 26.2 to 32.1 %, as a result of a decrease of its extraction by the urine, indicates an activation of the plastic processes in the youths' organisms after the ultraviolet irradiation. The increase of the positive balance of nitrogen from + 4.86 to + 5.63 g per 24 hours also attests to this.

In like manner, the data received by us in the process of the exchange investigations conclusively point our that a prophylactic irradiation of youths activates the exchange processes in the organism. After an ultraviolet irradiation, the capability of an organism to utilize the mineral elements, particularly calcium and even nitrogen, in food is increased to a significant degree.

Conclusions

1. The feeding of students in a trade school is conducted in accordance with the existing norms, but the content of nutritive substances in the students' rations, such as proteins, fats (especially animal) and calcium from the mineral substances, is lower than the physiological norms.

2. A prophylactic irradiation of the youths with ultraviolet rays significantly increase the capability of the organism to utilize the mineral substances and proteins of the food. The retention of calcium in the organism after the ultraviolet irradiation was raised from 34.9 to 62.4 %, phosphorus - from 22.2 to 41.9 % and nitrogen - from 26.2 to 32.1 %.

3. The results which were received enable the raising of a question concerning the increase in products of animal origin and vegetables in the nutrition of students and of the expediency in the organization of fotariev* (transliterated from the Russian text - this word is not included in any of the technical dictionaries available to the translator.).

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Table 1

The organic and mineral composition of the food ration in trade schools.

Composition of the ration.	According to the approved collection of produce	According to the data of the distribution menu.	According to the physiological norms
Proteins (in g)	86.32	95.11	119
Animal protein among them.	27.14	25.21	72 72
Fats (in g)	53.28	52.57	99
Animal fats among them.	35.92	41.25	84
Hydro carbons (in g)	542.62	553.11	471
Calorific value (in large calories)	3,062.	3,148.	3,340
Calcium (in mg)	642.	722.	1,000
Phosphorus (in mg)	2,223.	1,765.	1,500-2,000.

Table 2

The products included in the experimental food ration (in g).

Name	Quant.	Name	Quant.
Meat	40	Flour	17
Sausages	80	Macaroni products	40
Eggs	12.5	White-headed cabbage	600
Cheese	10	Onions	30
Butter	30	Carrots	100
Melted Butter	10	Potatos	100
Vegetable oil	10	Tomatoes	17
Milk	150	Dried fruit	35
Sugar	55	Wheat bread	200
Groats	50	Rye bread	500

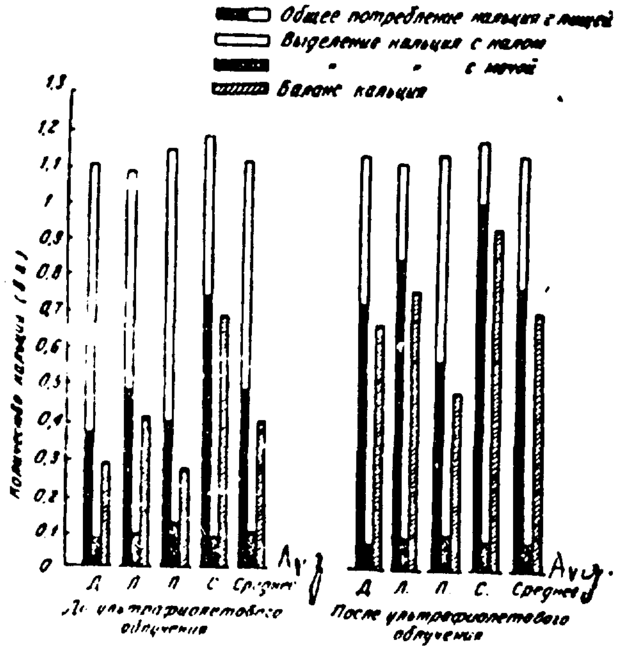

Рис 1. Обмен кальция у подростков (15—17 лет).

Graph 1. - Calcium Exchange in adolescents. (15-17 years).

Figures indicate the quantity of calcium in grams. The graph on the left is for the period prior to the ultraviolet radiation. The one to the right is for the period after the ultraviolet treatment.

Explanation of graph (from top to bottom): General Consumption of Calcium with the food.
Loss of Calcium with the feces.
Loss of Calcium with the urine.
Calcium Balance.

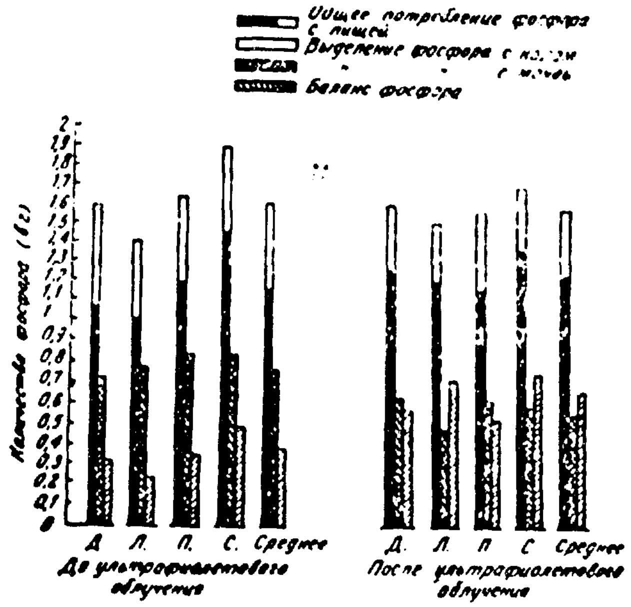

Рис. 2. Обмен фосфора у подростков (15—17 лет).

Graph 2. - Phosphorus exchange in adolescents (15-17 years).

Figures indicate the amount of phosphorus in grams. The graph on the left shows the amounts prior to the ultraviolet irradiation. The one on the right- the amounts after. The lines on the extreme right of each graph are the average.

Explanation of graph (from top to bottom): General consumption of phosphorus with the food.
Loss of phosphorus with the feces.
Loss of phosphorus with the urine.
Phosphorus balance.

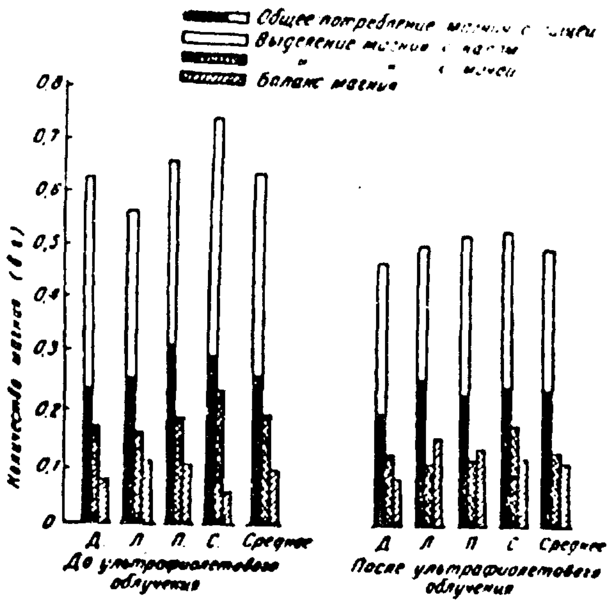

Рис. 3. Обмен магния у подростков (15—17 лет).

Graph 3. Magnesium exchange in adolescents (15-17 years).

Figures indicate the quantity of magnesium in grams. The graph on the left is for the period prior to the ultraviolet irradiation. The one on the right shows the amounts after the ultraviolet treatment. The lines on the extreme right of both graphs show the average.

Explanation of graph (from top to bottom): General consumption of magnesium with the food.
Loss of magnesium with the feces.
Loss of magnesium with the urine.
Magnesium balance.

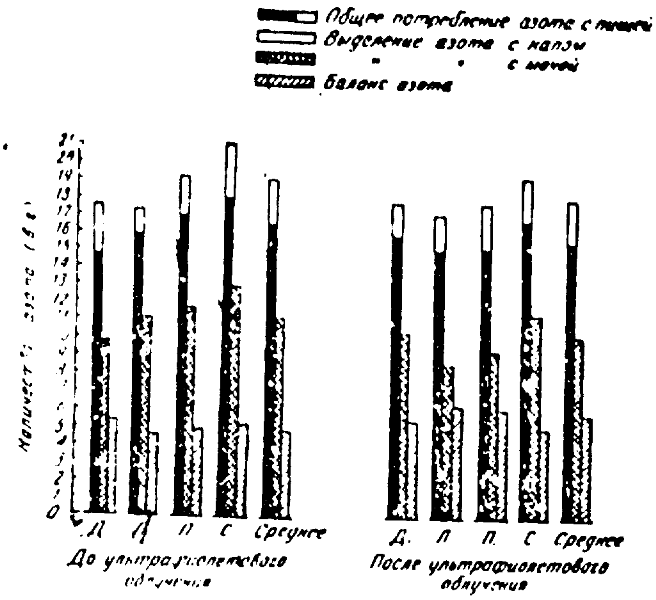

Рис. 4 Обмен азота у подростков (15—17 лет).

Graph 4.- Nitrogen exchange in adolescents (15-17 years).

Figures indicate the quantity of nitrogen in grams. The graph on the left is for the period prior to the ultraviolet irradiation. The one on the right shows the amounts after the ultraviolet treatment. The lines on the extreme right of both graphs show the average.

Explanation of graph (from top to bottom) : General consumption of nitrogen with the food.
Loss of nitrogen with the feces.
Loss of nitrogen with the urine.
Nitrogen balance.